REMARKS ON THE DISPOSAL OF REFUSE IN SOME EUROPEAN CITIES

BY

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REMARKS ON THE DISPOSAL OF REFUSE IN SOME EUROPEAN CITIES.

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In the summer of 1896 I spent some months on the other side of the Atlantic, visited some of the principal cities in England and Germany and inspected their different systems of refuse disposal. I do not propose, on this occasion, fully to recount my experiences; indeed, even if I were to do so, that would still be very far from exhausting the subject. I desire rather to put on record my impressions regarding these systems and their merits, considered more particularly with reference to the advantage of agriculture.

In order to avoid repetitions, I may, at the outset, state the meanings which I attach to the terms used in this paper, and which are intended to indicate the different sorts of city and town refuse, as well as the various systems in use for their removal. Following the example of W. H. Maxwell (Removal and Disposal of Town Refuse; 1898), I make use of the word "refuse" as a convenient general term for including every description of rejected and ejected matter. It comprehends house refuse, street refuse, trade refuse, factory refuse, etc., besides the liquid refuse which finds its way to the sewers. The term, house refuse, I would restrict to that which cannot, by any possibility, find its way to the sewers. It consists of kitchen refuse, garbage, ashes, cinders, etc. Street refuse is defined in the London Public Health Act of 1891 as "dust, dirt, rubbish, mud, road scrapings, ice, snow and filth," a formidable list to be the result of work described by the one word "scavenging." Excluding the "ice, snow and filth," a convenient word for the remainder might be found in the word "sweepings," which corresponds to the German *kehricht*. Of course, this would also exclude everything capable of finding its way to the sewers. Trade refuse consists of rejected animal and vegetable matter from markets and slaughter houses, while factory refuse might be understood to mean similar substances from cotton, woolen and other mills.

Sewage I take to be the liquid which flows in the sewers and which, in the greater number of instances, consists of human refuse, rain and storm water, wash water, including that from kitchen, baths, laundries, etc., and also all liquids from mills and factories. The latter part of the sewage it would seem to me to be practicable to characterize as

drainage, while the other part, consisting of feces and urine, combined with a certain quantity of flush water, constitute what might be called excretage. Drainage and excretage together make up sewage. Where the separate system of sewerage has been introduced this nomenclature would also find its application. The one set of pipes or sewers would contain the drainage, the other the excretage. In the case of towns where there are systems of water supply and sewerage, but no water closets, as in many German cities, the term drainage might also apply to the contents of the sewers. In many such instances, however, the excretage, or rather the excreta, would come together with the garbage, forming a compound for which there is no other name than manure. Where, in the production of the latter, an absorbent or deodorizer is used, a prefix might be necessary, and we should have earth, ash and moss manure, or compost, as the case might be. In my opinion, it is in the production of the latter that the greatest advantage to agriculture is to be obtained and the public health secured in the most economical manner. I do not mean to say that no other process of utilizing refuse is applicable to the fertilization of the soil, but I am inclined to maintain that in no other way can this be accomplished so economically as by the production of manures and composts.

Maxwell defines the term "conservancy system" as "the name given to the practice of retaining and collecting excreta and waste substances with a view of turning them to account as manure." This would seem to be too wide an application, and I propose to use the term as covering all privy, cesspool and midden systems which serve for the purpose of collecting and applying excreta direct to agriculture. It would then correspond to the "Gruben system" of the Germans. In some English reports the term "interception system" is applied when excreta are "intercepted" or prevented from passing into the sewers. This appears to me to be a convenient term for use when the intercepted matters are worked up by a manufacturing process into a concentrated manure. But it should not be regarded as equivalent to the "pan" or "pail" system, because in the corresponding "Kübel system" of the Germans the contents are not infrequently used without admixture and direct for agricultural purposes. In connection with sewage disposal the words precipitation, irrigation, etc., do not require explanation.

Sewage itself has no value. When fertilizing material of any description has once been allowed to mix with the large excess of water which comes from the clouds, its recovery is economically impossible. This is proved by the fact that where sewage can be conveyed into the ocean or into such large rivers as the St. Lawrence or the

Ottawa, no attempt is made to utilize it. If further proof were wanted that sewage is utterly valueless, the experience of the largest city in the world, London, provides it.

LONDON.

In the month of June, 1896, I visited the sewage works at Crossness on the north and Barking on the south side of the Thames, in company with Mr. W. J. Dibdin, chemist to the London County Council, and Dr. Thudichum, his assistant. At these places, in order to prevent the pollution of the Thames, the London sewage is treated by a precipitation process, the reagents being lime water, not milk of lime, and a saturated solution of copperas. This lime water is first run into the sewage and then the copperas. The proportions used are one part of the crystallized copperas to four or five of burnt lime. The additions increase the volume of the sewage about five per cent. After treatment it is passed through a long canal, dammed up at the far end, and here so-called "sludge" is deposited. This is a black mud which smells somewhat offensively and every chance is afforded it to consolidate and become as free as possible from water. Nevertheless, it contains about ninety per cent. of water when it is pumped into the special steamers which convey it fifty miles out to sea and there discharge it. It has been treated in filter presses and made into cakes containing only fifty-five per cent. of water, but no application or use was found for this product and its manufacture was discontinued. It contained nitrogen equal to one per cent. when stated as ammonia. The "sludge" is to be had gratis by any one who will undertake to use it in sufficient quantity. Seventeen thousand tons of it are produced daily. The present effluent is very slightly turbid and in color appears grayish. Its odor is somewhat disagreeable, although not to be compared with that of the "sludge." It has been experimented with on a filter bed of an acre area, and there is no doubt that its complete purification can be effected by intermittent filtration, if it is judged advisable to incur the cost. At present, however, the effluent escapes into the Thames and the degree of purification, as well as the condition of the river, is regarded as satisfactory. The discharged water is, of course, carried up and down by the tide, but creates no annoyance, and the opponents of this sewage purification system are now said to be satisfied.

The cost of the whole establishment is £120,000 annually for treating two hundred millions of gallons of sewage per diem. This $600,000 per annum is the price which London pays for the luxury of her water-borne system of sewage removal. I have no doubt that it

is the best system that such a city could adopt, and no one at the present time thinks of reducing its cost by attempting the application of the sewage or sewage products to agriculture.

LEYTON.

To the east of London and unconnected with its sewerage system are two municipalities, regarding whose method of sewage disposal I made some inquiries. At Leyton there are precipitation works, in which the precipitants used are twelve grains "sulphurous powder" and eight grains lime per gallon. The sulphurous powder is said to be alkali waste. The sludge produced is put through filter presses, with the addition of three per cent. quicklime. The resulting cakes smell of ammonia and are thrown aside as valueless. To prevent their causing any nuisance, destructors were being created to burn them, as well as the garbage, ashes, etc., which operation has since been successfully carried out.

WALTHAMSTOWE.

At Walthamstowe a precipitation process has been adopted similar to that of Leyton, although a sewage farm had previously been in operation. It was found impossible to apply the crude sewage to irrigation purposes without a previous separation of the sludge. The manager of the Walthamstowe sludge farm said that in order to use crude sewage, there should be one acre of land available to every one hundred of population, whereas, at Walthomstowe there is only one acre to three hundred. According to Gerson & Weyl (Rieeselfelder; Jena; Gustav Fischer; 1896), one hectare of land is necessary for the complete utilization of the sewage nitrogen from eighty persons. Since one ha. is equal to nearly two and one-half acres, it follows that one acre of land to thirty-two inhabitants would not be too much. At Walthamstowe the crude effluent from the precipitation process is led on to the various fields of the farm as required by these. Italian rye grass, mangold wurzel and vetches are the usual crops, but no grain is raised on account of the tendency it would have to "lodge." The fields were formerly under-drained, but on account of the difficulties of filtration, the use of the under-drains was abandoned and arrangements made for working the fields by surface flow. The sewage comes into contact, more or less, with the growing plant, or at least with the rye grass. I took occasion to smell several heaps of it recently cut, and it appeared to be perfectly sweet. It is mostly cut green for the use of cow-keepers, who say that more milk is obtained from it than with dryer fodder.

In spite of all this, so great are the difficulties, both at Leyton and Walthamstowe, that their authorities look forward with satisfaction

to the possibility of their being allowed to send their sewage into the London main sewer. This is the case, also, with the inhabitants on the west side of the River Lee, who would also be glad to have all their sanitary troubles ended in this way. There is no likelihood of the extension of the sewage farm of Walthamstowe, and no anticipation on the part of its authorities of being able to make money by agriculture.

BERLIN.

It was different with the system of sewage irrigation established in the city of Berlin. Its originators certainly anticipated, away back in 1870, that the agricultural operations would yield a profit. In July, 1896, I had the opportunity of attending the exhibition of that year in Berlin and of inspecting the magnificent exhibit made by the corporation authorities of everything connected with the management of the city affairs. Plans showing the limits of the several radial systems of collecting the sewage, photographs of the magnificent pumping machinery at the central stations, specimens of the huge iron pipes through which the sewage is forced up to the necessary level at the farms and a great many more interesting objects than I can mention here, were exhibited, so that it was quite possible to study the whole arrangement without going near the farms. I undertook, however, a visit to one of them, Malchow-Blankenburg, over which I was conducted by one of the intelligent inspectors in charge. The land is mostly let to market gardeners, and the rent includes the use of sewage for irrigation. Some of it is, however, worked by the city, on which grass is often cut four times a season and sold green in Berlin. Grain was also being harvested and looked well, while the vegetable growth was vigorous and healthy. It did not occur to me that there was anything to complain of in the smell of the sewage which was being applied, and from all I could learn, it was not in the slightest degree detrimental to the public health. I conversed with some of the market gardeners, who had nothing to complain of, except the low prices caused by over-production, and competition from Holland. One of them maintained that no money was to be made and that it was all being hoarded by the capitalists. He admitted that he had enough to eat, but no money. This gentleman was smoking a cigar at his work, and the horse and wagon were waiting for the cabbages he was cutting, to take them into the city. My friend, the inspector, told a different story, and said that good market gardeners could make plenty of money on the irrigation fields.

It would, of course, be the height of presumption for any one, paying, like myself, a short visit to Berlin and its irrigation farms, to indulge in criticism, or express any opinions whatever, based upon

his hurried observations. It is a great deal more profitable to pay some attention to the literature of the subject and to learn what the various authorities, who write both for and against the system, have to say about it. After studying their writings as much as my time has permitted, I have reached the following conclusions, which I place before you for what they are worth:

It has been calculated that the amount of nitrogen contained in the sewage used on the irrigation fields every year amounts to one thousand five hundred kilogrammes per hectare, and that the quantity contained in the crops harvested is only, at the most, two hundred kilo. per hectare. Eighty-six and two-thirds per cent. of the nitrogen thus appears to escape unutilized in the water of the drains. Analyses of the latter support the conclusion just stated and show that quantities varying from one-seventh to one-half of the organic substances of the sewage are found in the drain water. The most favorable results seem to be obtained with meadow land, from which the drain water shows an almost complete mineralisation of the organic substances. This does not, however, mean a complete utilization of the nitrogen, but only that that part of it escaping in the drains is in the form of nitrates.

The commission which was appointed by the state to control the irrigation fields stipulated for a surface of at least one hectare for the excreta of two hundred and fifty persons. Even with such a ratio as this, a considerable quantity of inorganic nitrogen, *i. e.*, nitrogen as nitric acid, supposed to be harmless to health, but known to be valuable for agriculture, will still be found in the drain water. In the year 1889 the following areas were used for the purification of the sewage:

At Osdorf, 1 hectare[1] for the excreta of 446 perosns.
At Grossbeeren, 1 hectare for the excreta of 538 persons.
At Falkenberg, 1 hectare for the excreta of 334 persons.
At Malchow, 1 hectare for the excreta of 242 persons.

At most of the farms, therefore, a quantity of sewage far in excess of that anticipated by the Royal Commission was on the fields, such an excess, in fact, as made the utilization of even the organic nitrogen and the purification of the sewage an impossibility.

It has been ascertained that, in order to utilize, by the growth of plants, the nitrogen in sewage from the excreta of eighty persons, an area of one hectare is necessary. That is to say, if we exact that the drain water of an irrigation field shall, just like the drain water of cultivated and manured land, not only be free from organic nitrogen, but also from all except the merest traces of nitrous or nitric acid or ammonia, then one hectare of land will be required for eighty persons.

[1] One hectare is equal to 2.471 acres.

In Berlin one hectare receives the excreta of five times this number, so that the irrigation fields are really troubled with an *embarras de richesse*. In 1896 the population of Berlin was stated at 1,604,303, and the extent of its irrigation farms 4,672 ha. This is equal to three hundred and forty-eight persons to each hectare.

According to the statements made by City Councilor Marggraff at the seventh international hygienic congress in London in August, 1891, with reference to the profits earned on the Berlin irrigation fields, the largest certainly in the world, it appears that they earned about that time two per cent. on their cost, or about one and one-half per cent. less than the rate at which the city can borrow money. This is all they have been able to do, without charging against the agricultural operations any of the cost incurred for pumping the sewage out to the farms. This is certainly not such a result as would induce other cities to imitate the Berlin system. Nevertheless it is not unlikely that such improvements may, in the future, be made in the management of this magnificent undertaking as to place it on a remunerative basis. As regards the direction in which such improvements are likely to take place, I should anticipate the introduction of a separate system of some sort, for keeping the storm water from the excretage, of apparatus for the thorough comminution of the latter, and the acquisition of a still greater amount of land for the complete agricultural utilization of the fertilizing constituents.

BIRMINGHAM.

In 1895 the population of the city of Birmingham was said to be 484,000 and the extent of its sewage farms 496.53 hectare, or 1,227 acres. It has, however, to be remembered that a large amount of the excreta never reaches the sewers, but is collected in "pans" and treated in the so-called interception works. About 215,000 of the population is accommodated in this way, so that the sewage farms have only to take care of the excretage of a population of 269,000, or about five hundred and forty-two persons to the hectare; a number two hundred higher than the Berlin ratio, above mentioned.

The sewage farms of Saltley and Tyburn differ from those of Berlin in so far as the sewage is subjected to a precipitation process before being used for irrigation. I walked over both the precipitation plant and the farms on the sixteenth of June, 1896. At the former the only precipitant used is lime, but it is in the form of milk of lime. Eleven tons of quicklime are said to suffice for the treatment of twenty-two millions of gallons in twenty-four hours.

Six hundred tons of sludge are produced daily, the disposal of which occasions a great deal of labor and trouble. It was at one time

allowed to collect on the fields in large quantity and in the wet condition, but the consequence was a serious nuisance. Now it is spread over the fields at Saltley in a layer eight or ten inches thick, and after it is somewhat dry it is trenched or dug into the land. This means burying it under eighteen inches or two feet of earth, which absorbs the smell. After this the land looks well enough, but it will not bear the weight of a horse. Even some time after the trenching is completed the sowing of rape seed has to be done by men drawing a drill. Usually Italian rye grass is the first crop, then come rape, barley, etc., until the fourth year comes round, when it receives another dose of "sludge." It is stated that the ground will yield good crops, but that it becomes "sick" from receiving too much "sludge." To me it appeared that there was no time to make any use of the fertility of the fields, owing to the necessity of disposing of the product of the precipitation process by continual trenching. In the neighbourhood of Saltley the smell of sewage prevails, and although it cannot be called offensive, it is less agreeable than in the neighborhood of other establishments of a similar character where solution of copperas is used in the treatment as well as lime.

The effluent from the tanks in which the sludge is deposited flows away down to Tyburn, the fields of which farm are well under-drained. Some fields are seen in beautiful bearing condition, while others appear to have just received their dose of sewage. The water escapes from the under-drains into a large brick-lined channel [illegible]rtainly looks clear enough, but seems to deposit a reddish [illegible] on the sides of the channel. It is still complained of, however, and the talk goes that more land is to be purchased for further purifying it. This final effluent escapes at Castle Bromwich, on the Midland Railway. As regards its composition I have not been able to find such details published as are given in the Berlin reports and which enable one to judge as regards the extent to which the fertilizing constituents of the sewage have been utilized.

I was informed on the spot that the cost to the city after deducting all the receipts for agricultural produce amount to $12,000 annually. According to the accounts for 1896 this loss amounted to over $17,000, altogether independent of interest on the capital expenditure, which amounts to over $400,000.

At the Montague street interception works I observed the manner in which garbage, ashes and excreta are handled. The latter is collected by the pan system, which was introduced in 1874, gradually replacing the twenty thousand cesspools then existing. The pans, which are made of galvanized iron, are cylindrical in shape, eighteen

inches in diameter and fifteen inches deep, and covered with a tightly fitting lid. The vans used carry eighteen pans and have a receptacle at the tail end into which the ash tub refuse is tipped. The garbage, ashes and breeze (or half-burnt coal) is riddled on octagonal rotating screens, which separate the fine ashes from the rougher material. The latter is further sorted by removing from it broken crockery, brick ends, tin cans, etc. What remains is in such a condition as to furnish fuel for raising all the steam which is required in the works, and might produce considerably more. The ashes or clinkers produced from the destruction of the garbage and coarse ashes, etc., are used for even more useful purposes than filling up low ground. They are applied in making concrete and are also ground, mixed with lime and water, and sold as ready made mortar. The steam from the boilers above the destructor furnaces is used for driving the engine, mills and other machinery, the latter being chiefly employed for the treatment of the excreta or night soil. As regards the latter, on reaching the works, the contents of the pans are emptied into tanks, where they receive an addition of about one per cent. oil of vitriol. Here the more solid portion settles, and is drawn off into a machine, where it is mixed with fine ashes from the rotating screens above mentioned. This forms an ash manure, which is taken out into the country and sold at varying prices, or given away to the farmers.

The more fluid part of the excreta is used for manufacturing a species of poudrette. Both steam and hot furnace gases are used for this purpose, the latter being preferred as cheaper and better. The evaporating apparatus consists of a revolving cylinder, charged with the liquid and through which the hot gases from the furnace pass direct. There are no stirrers inside, and the product is not discharged until it is semi-solid. It is then broken up into small pieces and completely dried. Its analysis shows:

	PER CENT.
Nitrogen stated as ammonia	7.49
Phosphoric acid total	3.23
Potash	2.97

This would have a value here of $24.38[1] per ton, and is said to sell in Birmingham at $6. Of course, it may be said that it costs more to produce it than it sells for, but this can also be said of the agricultural products of a sewage farm.

[1] Values of Fertilizing Constituents in Canada:

Nitrogen as Ammonia and Nitric Acid	13c	per lb.
Organic Nitrogen	12c	"
Phosphoric Acid, Soluble	6c	"
" Reverted	5½c	"
" Insoluble	5c	"
Potash	5¼c	"

The processes of refuse disposal adopted by the corporation of Birmingham are, to a large extent, the same as practiced in the other English towns which I visited. Therefore, instead of describing all that I saw at these places, I shall only point out variations from the Birmingham practice, besides mentioning particulars of importance which are peculiar to the localities visited.

MANCHESTER.

Manchester possesses precipitation works at Davyhulme, but no sewage farm. The excreta is "intercepted" to such an extent that only one-fourth reaches the sewers. A "storm overflow" is to be observed in the sewage canal in the yard of the works, but it is said that it is seldom that anything escapes there. The precipitants used are lime water, milk of lime and solution sulphate of iron, and after their introduction the whole mixture is agitated by waste compressed air. The sludge produced is mixed with slaked lime and then pumped through filter presses. Solid cakes are thus obtained, which is not possible without the slaked lime. On the other hand, a considerable amount of ammonia is liberated and passes into the water from the presses, which smells of it strongly. The cakes produced are valueless and are dumped over the "tip," where farmers are at liberty to remove them, and frequently do so. There is no doubt that they are capable of making excellent soil.

Eighty-six million gallons of sewage are treated every week, which quantity receives fifty-eight tons of slaked lime, containing forty per cent. water, and also fifty tons copperas. The wet sludge amounts to 93,448 cubic feet of sixty-five pounds each. To effect the pressing of this quantity sixty-six tons of slaked lime are used, and the product amounts to nine hundred and thirteen tons of pressed cake.

The effluent from the precipitating tanks is clear, slightly yellowish tinted and has no smell nor any very disagreeable taste, but it is not up to the standard of purity for being discharged into the river courses. Nevertheless, the most of it is so discharged, and only four millions out of thirteen million gallons daily are treated by a process of land filtration. It is allowed to flow on to fields which are well underdrained and which yield nothing agriculturally. There is about six feet depth of a loamy sand, or, in places, of loamy clay, and the final effluent which flows from the under-drains is quite clear, colorless, odorless and almost tasteless.

As regards the quantity of material used in the precipitation works for causing the "sludge" to subside, a comparison may here be made of the figures given me at Barking and Crossness (London), Saltley (Birmingham) and Davyhulme (Manchester). At the first-named

place four grammes of lime, or sixty-two grains, are said to be used to the gallon of sewage, which is equal to about four tons per million gallons. At Saltley only one-half a ton of lime is used to a million gallons of sewage. At Davyhulme the quantity stated is seven grains per gallon, which corresponds to one thousand pounds per million, or 0.45 tons. The quantity of copperas used at the London sewage works is about one ton per million gallons; at Manchester it is 0.58 tons.

Manchester has, like Birmingham, a "pan" or "pail" collecting system for huge quantities of excreta, which system, about ten years ago, replaced, not only the open cesspools, but also the ash-closet system, which used to be described as peculiar to Manchester and Rochdale. The latter system, which was thought to have many advantages, was abandoned because, as a general rule, the sifting of the ashes was not properly attended to by the inhabitants, and frequent cases of nuisance was the result. The present system resembles that of Birmingham so much that I need not take time to detail the unessential differences. The products are much of the same character, but in manufacturing the poudrette an addition is made of bone dust, in order to increase the percentage of phosphoric acid. The "Manchester corporation concentrated manure" is guaranteed to contain four per cent ammonia, ten per cent. phosphates, five phosphoric acid and one per cent. potash. This, at the rates for valuing fertilizers in use in Canada, would be worth $20.65 per twenty-two hundred pounds. In Manchester this quantity sells for £3, or $15. It has not been found possible to dispose of all the "ash manure" produced at the works of the corporation, and a great deal of it is utilized on the corporation estate at Carrington Moss. This property, comprising one thousand one hundred acres, and Chat Moss, with two thousand six hundred acres, both situated about ten miles from the city, close to the ship canal, have been acquired for the express purpose of receiving this and other refuse of the city. Such material as clinkers from the Water street and Holttown stations, street sweepings, which consist largely of horse manure, and market garbage are conveyed direct to these estates and utilized. I shall have something to say later on, as regards the great value of these properties for the purposes of the corporation.

OLDHAM.

At the Oldham destructor works the furnaces used are made by the Horsefall Company, of Leeds, and are said to offer many advantages. The material destroyed in them consists not only of "dry refuse," but also of household ashes, which are not even sifted. As a substitute

for the fine ashes in the night-soil works, cotton shoddy and other refuse from the mills of the place, is used. Of this two-thirds are used with one-third excreta to make manure, for which the farmers pay two shilling six pence per ton besides the cartage. The Oldham authorities propose to supplant the pail system by a water-borne system of sewage and precipitation works. The latter are not yet completed, although it is said that $300,000 have already been expended on them.

ROCHDALE.

The pail system was originated in Rochdale about the year 1870, and so was subsequently the manufacture of ash manure from excreta. In 1882 a new method of treatment was adopted for converting the whole of the excreta into poudrette, and since then no ash manure has been produced. Thus the fine ashes can be sent at once to the "tips" or "dumps." The poudrette or manure is said to contain eight and one-half per cent ammonia, eight and one-half per cent. tribasic phosphate of lime and five per cent, sulphate of potash. The offensive gases produced from the evaporation of the excreta are carried through what is called a "cremator," a brick chamber heated by gas coke, and thus everything in the shape of a nuisance is prevented.

While visiting Manchester and Oldham I had become aware that a certain degree of rivalry exists betwixt the pail system of collecting excreta, by which it is "intercepted," and the water-closet system, by which it finds its way to the sewers. Each has its adherents and the contention between them is sometimes sharp enough. In Rochdale, at the time of my visit, the pail system had the upper hand, and a population of 72,000 is served by it. There are only about six hundred and fifty water-closets in Rochdale, corresponding to a populaiton of three thousand. Besides this small amount of excreta, there are large quantities of domestic drainage and liquid manufacturing refuse, for the purification of which precipitation works and an irrigation farm are being constructed and laid out. Leaving out of consideration the expenditure connected with these new works, but including everything else connected with the collection and treatment of the refuse of the town of Rochdale, it may be said that, since the introduction of the poudrette manufacture, the gross receipts have amounted to one-third of the gross-expenditure.

GLASGOW.

The condition of the Clyde, which passes through the city of Glasgow, has long been instanced as an example of inexcusable river pollution. The dark, almost inky color of its water is, I believe, chiefly owing to the large amount of liquid manufacturing refuse produced

in chemical and copper-extracting works. Of course, there is an immense quantity of excretage, as well, in the sewage, but it is not alone to blame for the dirty condition of the River Clyde.

A beginning has been made at introducing a better state of things by the construction of the "Eastern District sewage purification works," at Dalmarnock, where about one-fourth of the water-borne refuse of Glasgow is treated. The processes employed resemble those of Davyhulme (Manchester), but sulphate of alumina is used instead of copperas, as a precipitant.

HAWICK.

In Hawick (population 22,000), a water-borne system of sewerage prevails and is, in fact, compulsory. When its enforcement began, the water supply was found to be insufficient and more had to be obtained. The original drainage of Hawick was on the surface, and that being uneven and hilly, storm-water was readily got rid of. It is still led off on the surface and very little of it finds its way to the sewers. Here we have a modification of the separate system, or at least a case in which the contents of the sewers consist of excretage only, the treatment of which is not interfered with or rendered abortive by large and sudden inflows of storm-water. Previous to any precipitation it is allowed to deposit, mechanically, some of its impurities by passing through two pretty large basins. The effluent from these, as it passes on, receives six to ten grains of ferrous sulphate and ten grains of quicklime to the gallon. This treatment has taken the place of one in which sulphate of alumina and a much larger quantity of lime were used. The resulting sludge deposits itself in some half dozen precipitation basins and the effluent from it is comparatively clear and has an alkaline reaction. It then flows through a series of ponds, where more deposition takes place. It is not further filtered or aerated and finds its way through an iron pipe fifteen inches in diameter into the River Teviot. It would seem that this effluent must be unusually rich in fertilizing substances, but I was not able to ascertain that any analysis had been made of it. The mechanical deposit, and the sludge from the precipitation basins and the ponds, all find their way into manure heaps, which are made up of these and the sweepings and garbage of the town, including ashes and other domestic and slaughter house refuse. This manure is sold at six pence per ton, delivered on the cars. To the farmers it is delivered at the rate of five pence per ton per mile, no charge being made for the manure itself. Two million gallons of excretage are thus treated daily at a cost of £1,500 annually.

In Dr. J. H. Vogel's "Utilization of City Refuse" (Verwerthung der Städtischen Abfallstoffe), published in 1896, particulars are given regarding the systems of refuse disposal practiced in five hundred and sixty-four German towns and cities, having a population from five thousand upwards. Of these ninety-two per cent. are still contented with the so-called Gruben system (conservancy system in England) for the collection of excretage, for the very good reason that it enables the authorities to prohibit human refuse from gaining access to the sewers. In 1896 I had an opportunity of observing the working of this system in Freiberg, a town of 30,000 inhabitants, and Leipzig, with a population of 400,000.

LEIPZIG.

In the latter city about one-tenth of the population make use of water closets, and the remaining nine-tenths of the ordinary "aborts," or privies, which are connected with the pits by glazed sanitary pipes seven to eight inches in diameter. The pits are usually placed in the court yards, are well built of stone or brick and have in the center of their floors a depression in which the end of the suction pipe from the receptacle wagons may be placed. A vacuum is created in the receptacle by an air pump placed on another wagon and driven by steam, and the contents of the pit are thus drawn up into the air-tight receivers. Any offensive gases drawn off by the pump are passed under the grate of the steam boiler and so destroyed. The system is the same as that in use in Dresden, Chemnitz, Stuttgart, Mannheim, Nüremberg and other German cities. The receptacles above mentioned are emptied into similar containers placed on railway wagons, by means of compressed air, produced by the same air pump and steam boiler used in emptying the pits. The railway wagons are then taken out to stations four or five miles distant from the city and there emptied by flow into lower-lying reservoirs of large dimensions. This is done to store it until required by the farmers, who pay for it at the rate of 2.20 marks per cubic meter, and cart it away themselves from the reservoirs. When delivered on the farms the price is three marks per cubic meter. When the stock accumulates it is often given away gratis. The mixed fecal matters are applied by the farmers at once in the fields. With reference to the water-closets, the excreta from them is not allowed direct access to the sewers. It is received into a pit and disinfected by the use of chloride of lime and other chemicals. From the first pit there is an overflow into a second, where further treatment takes place, as well as precipitation. The effluent here is under the inspection of a city official, who is supposed to test it in some way or other. The disinfecting is done by

the householder or by persons in his employment, and none of the expense of it is borne by the city or by the contractors who remove the refuse. The latter remove the substances deposited in these disinfection pits in the same manner as from those of the ordinary construction, but double rates are charged for the service. Strangers in Leipzig boarding at private houses sometimes complain of the smell from the water-closets, but the foreman in charge of the work of removing the refuse maintained that such cases were extremely rare.

FREIBERG.

In the town of Freiberg, Saxony, the sanitary arrangements are essentially the same as those of Leipzig, but on a smaller scale. There are a few water-closets but at least nineteen-twentieths of the population are served by the system of direct removal. The machines used for emptying the pits are worked by hand, and the escaping gases are passed through a charcoal fire in a small iron stove, attached to the pump, in order to accomplish their deodorization. Some of the excreta pits are very badly placed. One, which I saw being emptied in the old part of the town, was situated under the staircase of a tenement house. There was no smell developed, although the contents were constantly stirred to insure the effective working of the suction pipe. The receptacles on the wagons in which the pit contents are transported are constructed of wood, not iron. When loaded they are driven out of the town to a reservoir about two miles distant, which is built of brick, divided into two halves. These are covered with a wooden roof upon which a wooden ventilation shaft is erected with a height of about eighty feet. There is not much odor perceptible around the reservoir, nor does the discharge of a receptacle or the filling of the farmers' wagons occasion any difficulty. Upon the latter are placed wooden cylinders about 12 feet long and 2½ in diameter in a horizontal position. The excreta is pumped up out of the reservoir by a chain pump into a square stationary receiver, containing a cubic metre, for which the farmers are charged M. 1.50. So far there has been no difficulty in selling the product of the town at this rate.

BREMEN.

In Bremen, a city of 125,000 inhabitants, there exists what Dr. Vogel calls a mixed system of refuse disposal. Human refuse is excluded from the sewers, and about one-third of the inhabitants are served by the pit system above referred to. A peculiarity connected with it is the use of pneumatic receptacles for emptying the pits. These are placed on wagons, are made of iron and look like small

round boilers with a manhole in one end. These, when brought about ten miles out of the city, full, are discharged by simple gravitation into a reservoir, from which the farmers of the neighborhood are supplied. The boilers or receptacles when empty have a jet of steam thrown into them which drives out the air, and takes its place. Then the receptacles are securely closed. On their way back to the city they cool, the steam condenses, and a vacuum is formed. On arriving at the pit which is to be emptied the suction pipes which extend to the bottom of it are joined to the hose of the receptacle and the valve of the latter opened, when it is filled from the pit in about three minutes. Of course, it sometimes happens that there are obstructions, and occasionally the contents of the pit are not sufficient to fill the receptacle, but on the whole the system works well and dispenses with the engine or pumps used in Leipzig and elsewhere.

Another large portion of the excretage of this city is removed by a well-conducted pail system, and about 55 per cent. of the population is served in this way. A third system is also at work which consists in the use of moss litter as a deodorizer, absorbent and disinfectant. I inspected the working of this plan at the gas works where there are about 200 men employed, who use the closets at least during one shift. The receptacles, which looked like small casks, are placed under the seats, and are removed and emptied twice a week whether full or not. Every morning it is the duty of a workman to go to each closet and strew moss litter on the contents of the receptacles. All offensive odors are absorbed by it, and nothing disagreeable is to be observed in inspecting the closets. Four bales of moss litter are used per annum, averaging each 140 kilos, or about 1408 pounds in all. This is equal to seven pounds per annum per man on a twelve hours' shift. For twenty-four hours the yearly quantity required would be fourteen pounds per man. This is a very small quantity and shows that moss litter is far more effective as a deodorizer than dry earth, Moss litter is used extensively in private houses and automatic closets have been constructed to effect its proper admixture with the excreta. I inspected two of these at the Tivoli Theatre and the Hansa restaurant. In one case the self-working apparatus was out of order and in the other the box for containing the moss litter was empty. Under such circumstances the question arises as to whether the moss litter system would not work better without automatically constructed seats and special receptacles. There would seem to be no obstacle in carrying it out with the ordinary seats and well constructed pits in which the resulting dung might be allowed to accumulate for, say, six months before emptying. In towns irregularities might be prevented by specially detailing men to strew the moss litter. Whatever the

merits of this new system may be, there is no doubt that the use of moss litter as a deodorizer is increasing in Bremen, while other German towns such as Neumünster, Münden and Crossen a. O., have adopted the moss litter system exclusively, Münden going so far as to make its adoption compulsory.

BRAUNSCHWEIG.

On the other hand it has to be admitted that in Braunschweig, where the moss litter system was first introduced, the authorities have seen fit to resort to other means of refuse disposal. The population now exceeds 100,000, and the building of new houses with modern conveniences has caused the pollution of the sewers with excretage, which finds its way into the river Oker. To prevent any further contamination arrangements are being made for the treatment of the sewage by irrigation as in Berlin. I was informed, however, that for about one-half the population of Braunschweig the moss litter system is still praticed and that it works well. The resulting moss manure is not in the slightest degree offensive and has been proved to have a high agricultural value. Very thorough investigations have been made by such German scientists as Gärtner, Fränkel and Stutzer regarding the power which moss litter possesses of destroying bacteria. It has been found that when it is moistened with about 2 per cent. of sulphuric acid in a dilute condition it is capable of destroying every species of disease-breeding germs, and that its use is in the highest degree advantageous from a hygienic point of view. It is therefore not only an absorbent and deodorizer, but also a disinfectant. It contains from 0.75 to 1.75 per cent. of nitrogen in an inactive condition, but this becomes available after its return to the soil in the shape of moss manure. Its value in nitrogen alone is equal to $3 per ton.

Moss litter is produced in large quantity in North Germany and Holland, and is shipped from Rotterdam to London and even to Boston and New York for use in stables as bedding and as an absorbent. There are extensive bogs in Canada from which it can be produced, and the sample now before the meeting is from one now being worked in the County of Welland. Experiments have been made with it which show that 100 pounds are capable of deodorizing 800 pounds of excreta. Compared with dry earth its deodorizing power is at least eight times greater. It is equally effective with kitchen refuse, which in summer is a source of much annoyance to housekeepers. When this refuse is collected in a tub, and strewed over with a small quantity of moss litter all offensive odor disappears. Layer after layer may be thus treated and, when the tub is full, the contents can be easily burnt in a kitchen stove.

In these "remarks" I have pointed out the distinguishing features of the refuse disposal systems in fourteen cities and towns in England and Germany, as they appeared to me at the time of my visit. If we attempt to classify the systems described, as far as regards sewage disposal, we at once become aware of their exceeding diversity. In certain of the towns described, not far distant from each other, the systems are essentially the same. This is the case with London and Leyton, with Rochdale and Oldham, with Freiberg and Leipzig. But in all the others the systems are distinctly different as the following list shows:

London—Water carriage and precipitation.

Leyton—Water carriage and precipitation.

Berlin—Water carriage and irrigation.

Walthamstowe—Water carriage, precipitation and irrigation.

Birmingham—Conservancy by pail system, interception, water carriage, precipitation and irrigation.

Manchester—Conservancy by pail system, water carriage and precipitation.

Rochdale—Interception by pail system.

Oldham—Interception by pail system.

Glasgow—Water carriage, conservancy and precipitation.

Hawick—Deposition and precipitation.

Leipzig—Conservancy by pit system.

Freiberg—Conservancy by pit system.

Bremen—Conservancy by pit and pail systems, and moss litter system.

Braunschweig—Water carriage, irrigation, and moss litter sytem.

In these fourteen cities and towns it would therefore appear that ten different systems are in operation essentially differing from each other.

In the work above mentioned Dr. Vogel states that there is no one method for the disposal of town refuse which can be considered as the best and suitable for all circumstances and localities. Something to the same effect has been stated more than once in the reports of the Board of Health for the Province of Ontario. There is no universal medicine, and no system everywhere applicable with equal economy to the cleansing of a city. But it will readily be admitted that there are many methods in operation at the present day which leave much to be desired in æsthetic, hygienic and economic respects, and some of these imperfect methods have been described in this paper. If any of these are objectionable, then improvement is desirable, and it is for us to endeavor to ascertain the direction in which such improvement is most likely to be found. Each one of us has no doubt his convictions and perhaps prejudices on the subject. I confess that I have mine, based

largely, I claim, upon observations made in the localities above mentioned. With all due deference to the opinions of other members of this Association who have studied the subject, I shall state my views for what they are worth.

For cities I believe the direction of improvement lies in the exclusion from the sewers of storm and surface water, and the treatment of the excretage by comminution or precipitation and irrigation. It is very well known that in many precipitation works and also on irrigation farms the regular course of work is frequently interrupted and the proper utilization of the sewage prevented by sudden or long continued rains. By these the sewage is diluted, or carried away into the water courses sometimes without any treatment at all, complaints and suits for damages being the result. In the case of Hawick we have seen that it is possible to exclude surface and storm-water from the excretage in the sewers, and in all similar hilly localities, such as Birmingham for instance, it would seem comparatively easy to provide surface courses for the surface water. Where this is impossible there seems to be no other plan available, except the separate system, the drainage going direct to the water courses, and the excretage to the precipitation works and irrigation farms.

For towns of 30,000 population and under, I believe that improvement will be found possible by substituting the moss litter system for conservancy of every description. The reason why systems of direct disposal are so difficult to abolish lies in the fact that the introduction of any of the various systems which have been proposed in their place involves financial sacrifices which many communities cannot be persuaded to make. On the other hand to convert a conservancy into a moss litter system would seem to be a comparatively inexpensive undertaking. Much alteration would not be required in the existing conveniences, and the immediate result would be the production of an inoffensive manure, scarcely recognizable as such, which could be handled and transported without annoying anyone, and which would be welcome to the farmer as an excellent fertilizer. In order, however, to insure the successful working of the moss litter system it is before all things necessary that the town authorities should manage it and that a method of regular inspection should be carried out, so as to insure the proper and regular use of the moss litter. It is not to be expected that such a system would replace that of water carriage where it has been established, but there are many small towns where such a simple and effective plan of excreta disposal as that by means of moss litter could readily be established, and would be retained permanently even after the population had considerably augmented.

I may mention that the treatment of excreta by moss litter has long been in use at Caledonia Springs, Ont., and has given the most satisfactory results. I give this as an excellent practical example of the system which I look upon as the most effective and economical for towns and villages. With reference to the plan which seems to me ought to be recommended for cities, namely, exclusion of surface water, comminution and irrigation, our best example in Canada is that practiced at the Asylum for the Insane at London, Ont.

I cannot conclude this paper without again noticing Manchester and its peculiar troubles and surroundings. It appears that since the time of my visit the effluent flow from the sewage works at Davyhulme has not been giving satisfaction, and a scheme was proposed for conveying it to the estuary of the Mersey by means of a culvert. Subsequently this plan encountered violent opposition and had to be abandoned. The corporation of Manchester must by this time have almost arrived at the conclusion that to solve the sewage problem "passes the wit of man." At the same time it is the fact that the city owns 3700 acres of lands on the banks of the ship canal, underlying which there is a practically inexhaustible quantity of moss litter. By removing this, and utilizing it in the city for the manufacture of moss manure, an excellent dumping ground might be obtained for the less offensive refuse of the city, such as ashes, rubbish, etc. Upon this in course of time, and by means of the moss manure, the whole extent of both Chat and Carrington Moss might be converted into a most fruitful area, and made in fact to "blossom like the rose."